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Implementation of Project-Based Learning and Critical Thinking on Students' Learning Outcomes

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Abstract: This study seeks to assess the impact of critical thinking and project-based learning on student learning outcomes. This study employs a mixed-methods approach that integrates qualitative and quantitative research. This study employs an Explanatory Sequential Design and encompasses a cohort of 200 students. The random sampling method is employed for the sampling procedure. The researcher performed interviews with informants to acquire further information following the conclusion of data collection. The subsequent phase entails the administration of assessments to evaluate science learning results, after the collection of quantitative data using observation sheets, questionnaires, and test items. The preliminary approach of quantitative data analysis employs SPSS Statistics 26 software to produce descriptive statistics, assess hypotheses, and examine assumptions. Furthermore, for qualitative analysis employing the Miles and Huberman methodology. The hypothesis test results indicated that PBL significantly influenced student learning outcomes (Sig. = 0.005, correlation coefficient = 0.879), critical thinking also significantly affected student learning outcomes (Sig. = 0.002, correlation coefficient = 0.880), and both project-based learning and critical thinking collectively impacted student learning outcomes (Sig. = 0.000, correlation coefficient = 0.950). Implications for educational practices and curriculum development are derived from the results of this research. Initially, the investigation endorses the integration of critical thinking and project-based learning (PBL) exercises as a means to enhance knowledge retention, and ability to apply concepts in real-world contexts.

Keywords: Critical thinking; Learning outcomes; Project-based learning

Introduction

In education, critical thinking skills are indispensable, as they comprise students' capacity to systematize analyze, evaluate, and synthesize information (Fidiasih et al., 2025). In the 21st century, science education is not solely concerned with the acquisition of concepts; it also necessitates that students possess strong critical thinking skills and a strong understanding of science in order to address real-world issues. Critical thinking, creativity, innovation, problem-solving, and technological literacy are all essential skills that students must possess in order to learn science in the 21st century. In addition, the ability to consider critically is a critical skill for problem-solving. Students must possess the capacity to identify the underlying cause of an issue and develop suitable solutions. The acquisition of critical thinking abilities is feasible in numerous disciplines. Teachers are instrumental in the development and construction of educational programs that are designed to enhance this competency (Facione, 2011). Moreover, critical thinking is closely linked to

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creativity, as it involves formulating innovative solutions and fostering a reflective mindset. In the classroom, this skill manifests through students' willingness to explore challenges, communicate ideas, and accept constructive feedback (Supena et al., 2021). The inquisitive analysis of available knowledge to achieve profound comprehension is known as critical thinking (Owu-Ewie, 2010). Furthermore, the significance of teacher facilitation in the development of critical thinking is not to be disregarded (Susiloningsih et al., 2025).

The Indonesian education system, particularly in the field of science education, continues to manifest substantial deficiencies, despite the recognition of the significance of critical thinking. According to researchers, the cognitive and academic development of numerous pupils in high schools in Serang Regency was impeded by their inadequate critical thinking abilities. Additionally, the results of the student's education in the field of science in the regency of Serang. The low learning outcomes of pupils in science subjects are the result of learning that is still centered on the teacher (Aunurofiq & Setyasto, 2025). An ideal science curriculum should not only impart content knowledge but also foster inquiry, engagement, and the development of higher-order thinking skills. The objective of science education should be to cultivate individuals who are scientifically literate and possess the ability to analyze, solve problems, and make decisions. Nevertheless, this objective is not realized in practice as a result of instructional methodologies that do not effectively incorporate critical thinking (Sutiman et al., 2014). In the interim, the objective of this investigation is to ascertain the impact of critical thinking and project-based learning on the learning outcomes of students. Empirically, there is a scarcity of research that evaluates the concurrent effects of the integration of PBL and critical thinking on learning outcomes. The majority of studies prioritize immediate results, particularly academic grades, without examining the extent to which children can maintain these abilities over time.

The issue is compounded by the insufficient cultivation of pupils' critical thinking inside the classroom setting. The belief that critical thinking is inherent and unteachable leads to its disregard in educational practices. Critical thinking can be cultivated in structured environments that promote inquiry, tolerance for ambiguity, and effective learning processes (Anazifa & Djukri, 2017). Project-based learning (PBL) has developed as an effective strategy for fostering creativity and critical thinking. By involving students in addressing real-world challenges, Project-Based Learning (PBL) not only conveys knowledge but also fosters communication, teamwork, and adaptation. It is not only conveys knowledge to students but also augments their problem-solving capabilities, critical thinking skills, lifelong learning, communication proficiency, teamwork, adaptation to change, and self-assessment (Khoiri et al., 2013). Project-based learning utilises real-world challenges to captivate students (Farhan & Retnawati, 2014). The resolution of the issues will be facilitated by the flow of information among students during the problem-solving process. Educators facilitate discussions to facilitate the development of solutions. Project-based learning has a substantial impact on the learning outcomes of students by encouraging critical thinking (Hartini et al., 2014).

Prior research on project-based learning, critical thinking, and learning outcomes (Albeladi, 2022; Khan, 2017; Mutakinati et al., 2018; Nehru et al., 2024; Nisrina & Prasetyaningtyas, 2025; Octafianellis et al., 2021; Prajoko et al., 2023; Saefullah et al., 2021; Suyono et al., 2025; Widayati et al., 2025; Wisdayana et al., 2025) indicates that project-based learning enhances students' critical thinking abilities, thereby improving their academic performance. Based on previous research, a significant research gap remains: few studies have explored how the integration of PBL and critical thinking influences learning outcomes in a cohesive and systematic way. Additionally, the majority of prior research focuses on short-term outcomes, with limited attention given to longitudinal effects and the sustainability of these educational strategies over time.

To address this gap, the present study proposes a novel, integrated approach that combines project-based learning with critical thinking pedagogy. The uniqueness of this research lies in its comprehensive framework that not only evaluates immediate academic outcomes but also examines long-term retention and the development of critical thinking as a sustained competency. This study will adopt a mixed-methods design, collecting both quantitative and qualitative data to gain a holistic understanding of how these strategies interact and influence student learning. Furthermore, the study introduces an innovative pedagogical model that maps critical thinking development explicitly within the structure of project-based learning activities. This model is designed to be adaptable across various instructional settings, providing practical guidance for educators aiming to enhance both cognitive and academic performance.

This investigation endeavours to ascertain the impact of critical thinking and project-based learning on student learning outcomes. In accordance with the established research objectives, the enquiries for this study are articulated as follows: What is the effect of implementing project-based learning on student

learning outcomes?; How does student critical thinking influence learning outcomes?; What is the impact of implementing project-based learning and critical thinking on student learning outcomes?

Method

This study utilizes a mixed-methods strategy that integrates qualitative and quantitative research. Mixed techniques, also known as the previously described research methodology, integrate qualitative and quantitative methodologies (Johnson et al., 2007). A hybrid methodology allows researchers to investigate both quantitative and qualitative dimensions, integrating thorough enquiries with systematic data synthesis and analysis (Cortini et al., 2019). This mixed-method study employs a progression from simplicity to complexity by integrating three paradigms: dialectical attitude, critical realism, and pragmatism (Kansteiner & König, 2020; Schoonenboom, 2019). Quantitative methods are typically defined as traditional, positivist, scientific, and exploratory approaches. Qualitative techniques are often characterized as contemporary, post-positivist, innovative, and interpretive research methodologies (Yusnidar et al., 2024). This research design employs Explanatory Sequential Design, a two-phase mixed methods approach in which the researcher initially collects and analyzes quantitative data, followed by qualitative data collection and analysis to elucidate or elaborate on the quantitative findings. The study was carried out in a State Senior High School located in Serang regency, with a primary emphasis on eleventh-grade students. The selection of schools was conducted following a thorough assessment of various criteria: Availability for Grade XI: The selected schools were determined by their offering of Grade XI, which is pertinent to this study; and Accessibility: The schools were selected for their favourable Geographical location, providing convenient access for the researcher and ensuring an uninterrupted data collection process. The objective of this study was to ensure the incorporation of socio-economic diversity in the Serang regency by selecting schools that reflect a variety of student and teacher backgrounds. This methodology was employed to ensure that the research findings accurately reflect the diverse socio-economic context of the region. Consequently, the methodology of school selection is essential for ensuring an accurate representation of the population under investigation, specifically the students in the Serang regency. The current research encompassed a cohort of 200 students. A random sampling method was utilised for the sampling process.

In order to gather data regarding students' critical thinking, this investigation implemented an observation sheet that comprised twelve valid statement items that were assessed on a five-point Likert scale. In addition, the assessment of students' science learning outcomes was conducted using 20 valid multiple-choice questions with a Cronbach's alpha of 0.88. Qualitative data were obtained by conducting interviews with informants using a valid interview questionnaire. The instrument preparation was the initial stage in the study. The researcher conducted observations on the sample that would be targeted after obtaining permission. This entailed the completion of the science learning outcome skills observation sheet and the distribution of the critical thinking questionnaire and question sheet to high school students in the XI grade. The researcher conducted interviews with informants to acquire further information following the completion of data collection. The subsequent phase involved administering a test to determine the science learning outcomes, following the acquisition of quantitative data through observation sheets, questionnaires, and question sheets. Subsequently, qualitative data obtained from structured interviews were examined to derive conclusions. The final stage involved formulating exhaustive conclusions that were informed by the combined quantitative and qualitative data. Two data analysis strategies were implemented in this investigation. Quantitative data analysis is the initial method, which involves the use of SPSS Statistics 26 software to generate descriptive statistics, evaluate hypotheses, and test assumptions. Hypothesis testing was preceded by the execution of conventional assumption tests, including normality and linearity. The hypothesis tests implemented were the paired sample T-test and the person correlation test. The objective of this method is to enhance the validity of quantitative data analysis by integrating the results of qualitative data that has been obtained through interviews with specific sources. Miles and Huberman's qualitative data analysis methodology (Miles et al., 2013) three phases of data analysis as proposed by Miles and Huberman: Data reduction is the process of choosing, concentrating, reducing, abstracting, and transforming raw field data into a more structured format. Reduction occurs continuously during the study process, rather than solely post-data collection; Data Presentation (Data Display) involves carefully organizing data to facilitate the drawing of conclusions. The objective is to facilitate researchers' ability to discern patterns, correlations, or categories within the data; and Conclusion drawing and verification is the process of extracting meaning or interpretation from reduced and displayed facts. Initial conclusions may be provisional, although they undergo rigorous verification to ascertain their veracity.

Result and Discussion

Table 1. Description of project based learning

Schools	Interval	Category	F	%	Mean	Median
A	100–109	Not very good	0	0	55	45.5
	110–119	Not good	3	2.5		
	120–129	Good	35	42.5		
	130–139	Very good	62	55		
B	100–109	Not very good	0	0	60	55
	110–119	Not good	2	3.75		
	120–129	Good	40	42.5		
	130–139	Very good	58	53.75		

The Table 1 presents the results of descriptive statistical analysis concerning the effects of project-based learning on students' learning outcomes.

Project-based learning at School A is predominantly classified as very good, accounting for 55% of the aggregate number, as indicated by the statistics presented in Table 2. The very good category is also highly represented in project-based learning at school B, comprising 53.75% of the total.

Table 2. Description of critical thinking

Schools	Interval	Category	F	%	Mean	Median
A	140–149	Not very good	0	0	60	60.5
	150–159	Not good	1	2		
	160–169	Good	40	39		
	170–180	Very good	59	59		
B	140–149	Not very good	0	0	55	55
	150–159	Not good	2	2.5		
	160–169	Good	39	55		
	170–180	Very good	59	42.5		

The majority of critical thinking at School A falls into the very high category, comprising 59% of the total, as indicated by the numbers in Table 3. School B has a rather high prevalence of the most prevalent involvement category, which accounts for 42.5%.

The data in Table 3 indicate that 53% of students in School A exhibit a high level of learning outcomes, qualifying them for the "very good" category. Furthermore, the percentage of students in the exceptionally excellent group at School B is 58.5%. The researcher conducted empirical tests to verify the assumptions and ensured that the data followed both a normal and linear distribution before evaluating the hypothesis. This facilitates a more thorough evaluation of hypotheses. The statistical evaluation in this study is conducted utilizing the T-test and correlation analysis. This test is employed to detect statistical correlations and discrepancies between the variables analyzed from the two educational institutions.

Table 3. Description of learning outcomes

Schools	Interval	Category	F	%	Mean	Median
A	89–98	Not very good	1	1.25	70	60
	99–108	Not good	5	5.25		
	109–118	Good	44	40.5		
	119–128	Very good	50	53		
B	89–98	Not very good	0	0	75	65
	99–108	Not good	5	5.25		
	109–118	Good	35	36.25		
	119–128	Very good	60	58.5		

Table 4. Analysis of the T-test findings for project based-learning, critical thinking, and learning outcomes

Variables	School	N	Sig. (2-tailed)
Project based learning	School A	100	0.000
	School B	100	0.001
Critical thinking	School A	100	0.002
	School B	100	0.005
Learning outcomes	School A	100	0.000
	School B	100	0.003

Table 4 presents the t-test results, indicating a significant value below 0.05. There is a significant disparity between the two benchmark school regarding learning outcomes, critical thinking, and project-based learning.

Table 5. Summary of the correlation test findings for project based learning, critical thinking, and learning outcomes

School	X	Y	Sig. F Change	Pearson Correlation
A	Project based learning	Learning outcomes	0.005	0.879
	Critical thinking		0.002	0.880
	Project based learning and Critical thinking		0.000	0.950
B	Project based learning	Learning outcomes	0.001	0.887
	Critical thinking		0.000	0.855
	Project based learning and Critical thinking		0.000	0.920

Table 5 presents correlation test results that demonstrate a statistically significant correlation between the learning outcomes (Y) as the dependent variables and the independent factors (X) of critical thinking and project-based learning. The significance value is less than 0.05. The robust correlation between these variables is evidenced by the Pearson correlation coefficients of 0.879 and 0.887. After the quantitative results have been clarified, our qualitative findings focus on qualitative data, non-numerical indicators, and research analysis. Three qualitative analysis parameters are employed to characterize the results. This study's efficacy in evaluating learning outcomes concerning several aspects of critical thinking and project-based learning is specifically assessed in the analysis. The pertinent conclusions are determined by the study of the qualitative data. All qualitative conclusions are based on descriptive statistical findings. The qualitative findings are presented within the context of their respective qualitative frameworks. Comprehensive information regarding the qualitative data collected from interviews is provided in the subsequent text.

Project-Based Learning

Q1: What is your perspective on project-based learning?
S1: The teaching style of Project-Based Learning is compelling because of its integration with the real world.
S2: The Problem-Based Learning approach presents unique challenges.
S3: The practical application of Project-Based Learning is exceedingly challenging, and we are extremely satisfied.
Q2: What are the advantages of Project-Based Learning for students in the classroom?
S4: The application of critical thinking abilities is essential for the completion of class projects.
S5: Collaborative problem-solving with peers in teacher-assigned assignments.
S6: The integration of classroom lessons with real-world applications.

Critical Thinking

Q1: Which aspects of the classroom teachings do you find particularly enjoyable?
S1: I prefer to acquire knowledge through empirical learning, followed by assessments of my retention.
S2: I believe this instruction will enhance my comprehension of the universe.
S3: I am confident that this course will yield exceptional outcomes.
S4: The sole prerequisite for this course is memorisation.
Q2: Are the classroom teachings consistent with real-world applications?
S5: I hold the opinion that a considerable number of educational teachings are not aligned with the facts.
S6: The educational courses are tedious and do not offer sufficient challenge.
S7: The academic curriculum is predominantly theoretical and does not align with practical realities.

Learning Outcomes

Q1: What is the correlation between critical thinking and learning outcomes in scientific subjects?
S1: Critical thinking enhances students' comprehension of educational concepts, hence improving their academic performance in science subjects.
S2: The critical thinking of students is crucial in their ability to make conclusions from science learning, which subsequently influences their academic performance.
S3: Critical thinking is essential during the learning process to provide students with the ability to predict solutions to existing issues.
S4: Critical thinking is inextricably linked to learning outcomes in science education, since students are continually confronted with challenges about their comprehension of the subject matter.
Q2: What is the correlation? What is the relationship between students' learning outcomes and their critical thinking skills?
S5: The development of students' enthusiasm for learning is facilitated by critical thinking, which in turn enhances their science learning outcomes.
S6: The learning outcomes are influenced by students' critical thinking, as it fosters their interest in the study of science.
S7: Critical thinking is essential for the learning process, as it strongly influences students' engagement in class, which in turn affects their learning outcomes.
S8: The learning outcomes of students are closely correlated with their learning interests, since students must possess a high level of interest and enthusiasm for the subject matter in order to learn science.

This study poses three research enquiries. The core inquiry is: What effect does the implementation of Project-Based Learning have on the learning outcomes of high school students in Serang Regency? The study's results reveal that Project-Based Learning significantly influences the educational outcomes of high school students in Serang Regency. The findings of this study support prior research demonstrating that the implementation of Project-Based Learning enhances student learning outcomes (Bashith et al., 2024; Desyafrianti & Ainin, 2024; Fadhilah et al., 2023; Febriana, 2017; Firdaus et al., 2023; Nurfikri et al., 2022; Simbolon & Koeswanti, 2020). Previous studies have examined the enhancement of student learning outcomes through project-based learning. Previous

studies on the project-based method of learning were driven by the desired outcomes of the project to be achieved during the educational process. The primary focus is on their thorough project procedure (Farihatun & Rusdarti, 2019; Lubis et al., 2019). Learning outcomes refer to the results attained by an individual through conducted activities, resulting in modifications in behaviour. Learning outcomes necessitate prior acquisition of knowledge. Learning is not confined to the comprehension of theoretical concepts; it also encompasses the mastery of habits, perceptions, joys, interests, talents, social adaptation, skill types, goals, desires, and hopes (Hadiyati & Wijayanti, 2017).

The second research question is: How does critical thinking influence the learning outcomes of high school students in Serang Regency? The findings of this study demonstrate that students' critical thinking significantly influences learning outcomes, as evidenced by research conducted at Schools A and B in Serang Regency. The outcomes of this study are consistent with previous research (Kurnianto et al., 2020; Nurvitasari & Sukartono, 2022; Silvia et al., 2021; Syamsinar et al., 2023; Wandira et al., 2024). The results of this study demonstrate that critical thinking significantly influences student learning outcomes. Critical thinking demonstrates the ability to assess knowledge, ascertain its relevance, and subsequently interpret it for the purpose of problem-solving. This necessitates sophisticated cognitive functions, encompassing analysis, assessment, equity, and reflection (Mutakinati et al., 2018). The third research question is: What is the influence of project-based learning and critical thinking on the learning outcomes of high school students in Serang Regency? The findings of this study illustrate a substantial correlation between the implementation of project-based learning and critical thinking concerning the educational outcomes of high school students in Serang Regency.

This research introduces novelty by examining the combined effects of Project-Based Learning (PBL) and critical thinking on students' learning outcomes, offering a fresh perspective on how these pedagogical approaches interact to enhance educational effectiveness. While prior studies have typically explored PBL or critical thinking in isolation, this research uniquely investigates the synergy between the two, examining how PBL can serve as a platform for developing critical thinking skills and, in turn, how these skills impact students' academic performance and problem-solving abilities. Furthermore, this study introduces specific, measurable indicators for assessing how critical thinking within a PBL framework influences learning outcomes across many subjects, allowing for a more nuanced understanding of the process. The results offer new insights into the effectiveness of PBL and critical thinking integration, contributing valuable data for educators seeking evidence-based strategies to enhance student engagement, knowledge retention, and practical application of skills.

Several substantial implications for educational practices and curriculum development are derived from the results of this research. Initially, the investigation endorses the integration of critical thinking and project-based learning (PBL) exercises as a means to enhance students' engagement, knowledge retention, and ability to apply concepts in real-world contexts. For educators, this research underscores the significance of integrating Project-Based Learning (PBL) with activities specifically designed to foster critical thinking, indicating that these methodologies can result in more meaningful and enduring learning outcomes. Schools and curriculum developers can leverage these insights to design lesson plans that prioritize critical thinking within project-based frameworks, enabling students to cultivate essential problem-solving and analytical skills that are vital for success beyond the classroom.

This study offers significant insights, however it possesses multiple drawbacks. The sample size is somewhat small and restricted to two schools in the Serang district, thus impacting the generalisability of the results. Subsequent study ought to encompass larger and more heterogeneous samples to corroborate the findings. This study concentrated on short-term outcomes; longitudinal research is necessary to evaluate the long-term effects of project-based learning and critical thinking. Subsequently, future investigations ought to examine the viewpoints of educators and parents to attain a more thorough comprehension of the elements that affect the execution of project-based learning and critical thinking in educational institutions.

Conclusion

The findings of this study demonstrate that project-based learning influences student learning outcomes, as indicated by a significance value of 0.005 and a correlation coefficient of 0.879. Additionally, critical thinking significantly impacts student learning outcomes (Sig. = 0.002, correlation coefficient = 0.880). Furthermore, both project-based learning and critical thinking together affect student learning outcomes (Sig. = 0.000, correlation coefficient = 0.950). This study presents concrete and measurable indicators to evaluate the impact of critical thinking within a PBL framework on learning outcomes in Science topics, facilitating a more nuanced comprehension of the process. The findings provide novel insights into the efficacy of combining PBL with critical thinking, supplying

essential data for educators pursuing evidence-based methodologies to enhance student engagement, information retention, and the practical application of skills. The practical implication of these findings is that educators might incorporate the SSI approach in lesson design to establish links between scientific principles and societal challenges. These results underscore the necessity for schools to establish curricula and supply instructional resources that foster critical thinking and scientific literacy within both local and global settings. Future study should investigate the long-term effects of project-based learning and critical thinking across multiple school settings and create a broader array of materials to enhance science teaching.

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The authors declare no conflict of interest.

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